SD-101

POWER SPECTRAL DENSITY ANALYSIS SYSTEM

Calibration Copy

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276-2331

October 1962

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SYSTEM DESCRIPTION:

The SD-101, being a frequency tuned unit, is tuned synchronously to the frequency from the sweep oscillator. The frequency range of the sweep oscillator is from 5 cps to 5 kc. The SD-101 accepts the input data signals, passes the spectrum through either one of two selectable plug-in type crystal filters, and provides a linear DC output proportional to the average level contained in the filter.

This average value is then passed through a logarithmic converter, producing the equivalent of the log of the mean squared volts from the Analyzer. This output from the log converter is then connected to the "Y" axis of the plotter. The X-Y plotter will be set up with log e^2/cps, or g^2/cps scales and the "X" axis is the logarithm of frequency. This allows the continuous plot of the power spectral density of the input versus frequency. Bandwidth division is only an attenuation constant which can be employed during calibration of the X-Y plotter scale when using either an external calibration signal or the internal calibration signals provided in the SD-101. Automatic bandwidth change at a given frequency can be accomplished by a modification to the SD-101. This modification would consist of relay selection of a wider bandwidth at a pre-determined frequency cross-over point.

The filtered output of the SD-101 may be utilized to display the data signals on an oscilloscope, or to read true rms levels of the filtered input, and eventually could be combined with additional Analyzers to form the basis of a cross-spectral analysis system.

The system offers tremendous versatility in operation; requires little space; and the SD-101 can be programmed from other external sources, such as tape, other external oscillators, etc.

The automatic band switching, if required, does not form a part of the system, but could be installed by the customer at a later date.

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October 1962

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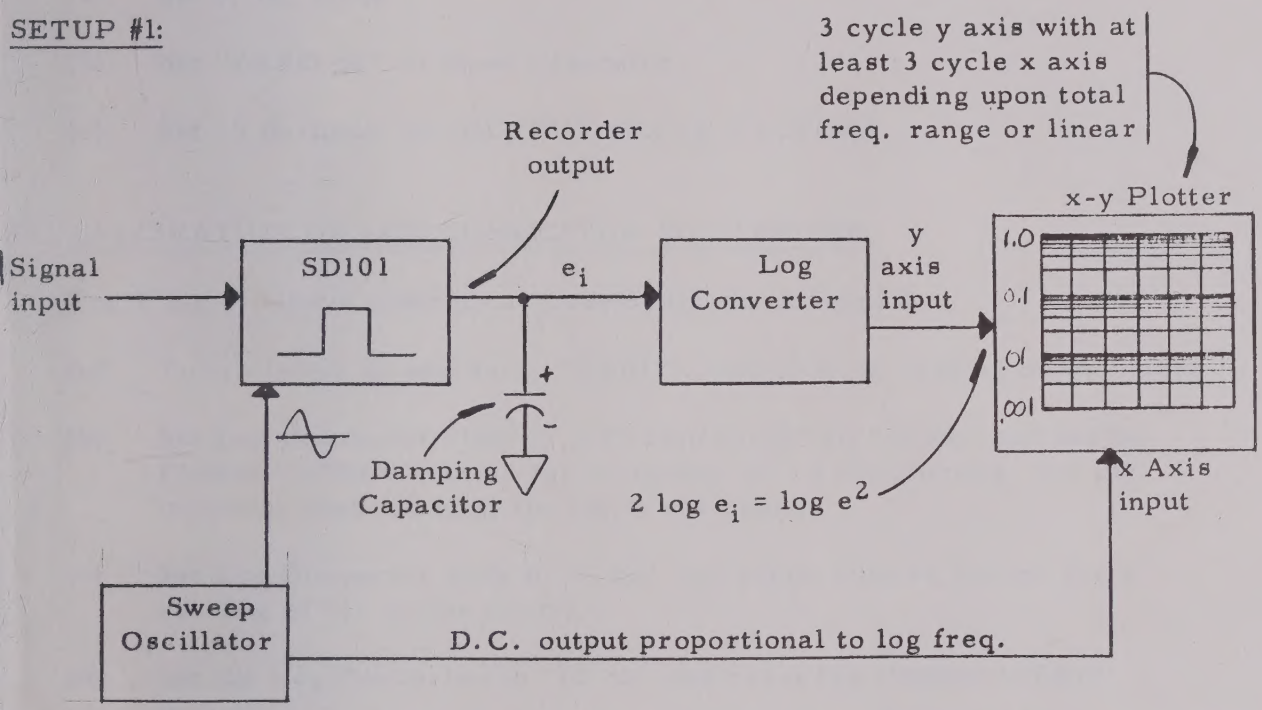
CALIBRATION OF SD-101 DYNAMIC ANALYZER FOR POWER SPECTRAL DENSITY ANALYSIS

SETUP #1:



CONTROL KNOB SETTINGS:

1. SD-101

   (a) Set to "CAL"

   (b) Select filter bandwidth desired

   (c) Adjust "FREQ" for peak indication on meter

   (d) Adjust "GAIN" for meter reading of "7"

   (e) Turn "RECORDER OUTPUT" control fully clockwise

CALIBRATION OF SD-101 FOR PSD ANALYSIS

II. LOG CONVERTER (Assuming a Moseley Log Converter)

(a) Set to DC mode

(b) Set "ZERO db" on input attenuator

(c) Set "5 db/inch" on "OUTPUT SCALE FACTOR"

III. CALIBRATION OF LOG CONVERTER TO PLOTTER

For 2 log e_i, leave controls as previously set in I and II.

(a) Turn Plotter on and set "ZERO" control for a reading on the chart

(b) Set Log Converter "INPUT ATTENUATOR" to "10 db" and set the Plotter "ZERO" control for a reading of ".1" (assuming, for the moment, that "1" is at the top of the chart).

(c) Set Log Converter back to "0 db" and adjust Plotter "Gain" for a reading of "1" on the chart.

(d) Set the Log Converter to "10 db" and reset the Plotter "ZERO" to ".1"

(e) Set the Log Converter to "0 db" and adjust the "GAIN" for a reading of "1"

(f) Continue repeating this procedure until the 10 db range changes on the Log Converter producing a 10 to 1 or 20 db or 1 cycle change on the chart. When this is accomplished, the Log Converter is calibrated to the Plotter for 2 log e_i, which is an identity for log e^2. Dividing by bandwidth is nothing more than changing the Plotter "ZERO"

IV. CALIBRATION SIGNAL

The SD-101 is providing the calibration signals from an internal standard. The Cal equivalent is derived as follows (For Setup #1 only):

IV. CALIBRATION SIGNAL (Continued)

$$\text{Cal} = \frac{(.84 \text{ Full Scale})^2}{\text{effective squared filter bandwidth}}$$

$$\text{Full Scale} = \frac{\text{SD-101 Range x Multiplier setting (millivolts)}}{\text{Pickup sensitivity (millivolts/g)}} = \text{g's full scale}$$

Note: The effective squared bandwidth of a 20 cps filter is approximately 17.6 cps; the effective squared bandwidth of a 5 cps filter is approximately 4.6 cps

The .84 is derived from the fact that the Recorder output is the average value of the voltage contained in the filter band. The ratio between rms/average = 1.2 for the SD-101. In other words, the SD-101 would produce a given output for a sine wave input and for a random input, the SD-101 output will be lower than the true rms value by the ratio of 1/1.2. Therefore, 1.2 x SD-101 output = rms.

Since the SD-101 meter on "CAL" is set to ".7" full scale as a reference line, then .7 x 1.2 = .84 full scale for the tru rms level when measuring the random signal.

Example: A pickup sensitivity of 10 mv/g, 20 cps filter in SD-101 and an anticipated operating level of 8 g's rms from the shaker.

Note: The rms voltage setting of the "RANGE" c ontrol must not be exceeded. (8 g's x 10 mv = 80 mv allowing the SD-101 to be operated on the .IV scale)

Using the above:

$$\text{Full Scale} = \frac{100 \text{ mv} \times 1}{10 \text{ mv/g}} = 10 \text{ g's}$$

$$\text{Cal} = \frac{(.84 \times 10)^2}{17.6} = \frac{70.6 \text{ g}^2}{17.6} = \frac{4\text{g}^2}{\text{cps}}$$

(a) Set the Plotter "ZERO" to "4" in the upper portion of the chart and the system is calibrated with that point representing 4 g^2/ cps

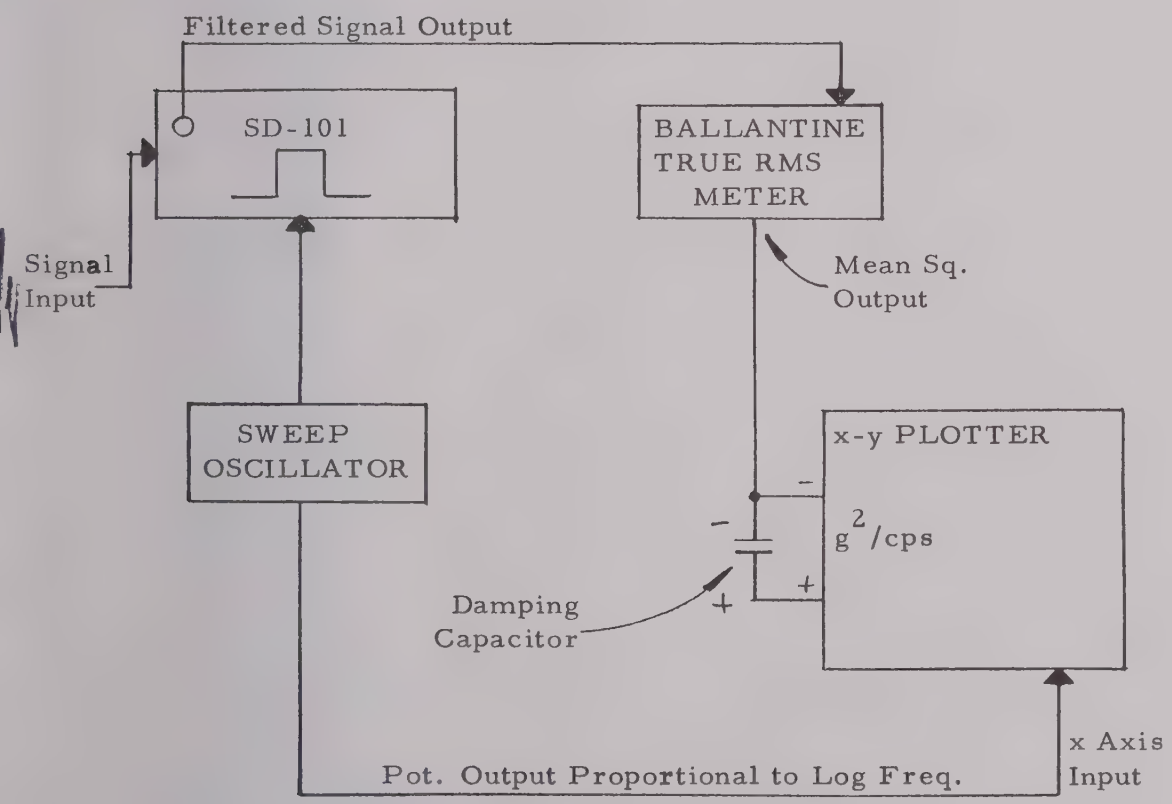
(b) Set the SD-101 "RANGE" and "MULTIPLIER" to .1 and 1.0, respectively, and the system is ready to operate.

IV. CALIBRATION SIGNAL (Continued)

(c) If it is desired to make the same point on the chart .4 g^2 cps instead of 4 g^2 cps, change the "MULTIPLIER" setting from 1.0 to .3 and you have increased the SD-101 sensitivity 10 db which produces a 20 db increase in the Plotter sensitivity.

Note: Setup #1 can also be used as follows: By-passing the Log Converter and then squaring the resulting plot manually.

SETUP #2:



CALIBRATION OF SD-101 FOR PSD ANALYSIS

CONTROL KNOB SETTING:

I. SD-101

(a) Set to "CAL"

(b) Adjust "FREQ" for peak on meter

(c) Set "GAIN" for meter reading of "7"

(d) Meter reading of 7 volts on the Ballantine (the mean^2 output plug cannot be inserted during this adjustment)

II. CALIBRATION OF PLOTTER TO BALLANTINE

(a) Use Linear "Y" Scale

(b) Turn Plotter on and adjust "Y ZERO" for an on-scale indication. (Plug in "MEAN SQUARE OUTPUT")

(c) Change the Ballantine "ATTENUATOR" 10 db to a higher scale (less sensitive range)

(d) Set the Plotter "ZERO" to ".1" of the desired full scale deflection

(e) Turn the Ballantine attenuator to its original position (10 db more sensitive) and adjust the "GAIN" of the Plotter for full scale.

(f) Repeat steps (c), (d), and (e) until a 10 db chan ge in the attenuator produces a 10 to 1 (20 db) change in the Recorder deflection.

III.

$$\text{Cal} = \frac{(.7 \text{ Full Scale})^2}{\text{Effective squared filter bandwidth}}$$

$$\text{Full Scale} = \frac{\text{SD-101 Range (millivolts)}}{\text{Pickup Sensitivity (millivolts/g)}}$$

CONTROL KNOB SETTING (Continued)

III.

Example:

P/U Sensitivity= $\frac{10 \text{ mv}}{\text{g}}$ Full Scale = $\frac{100 \text{ mv}}{10 \text{ mv/g}}$ = 10 g

10 g's (pms) operating level - 20 cps filter

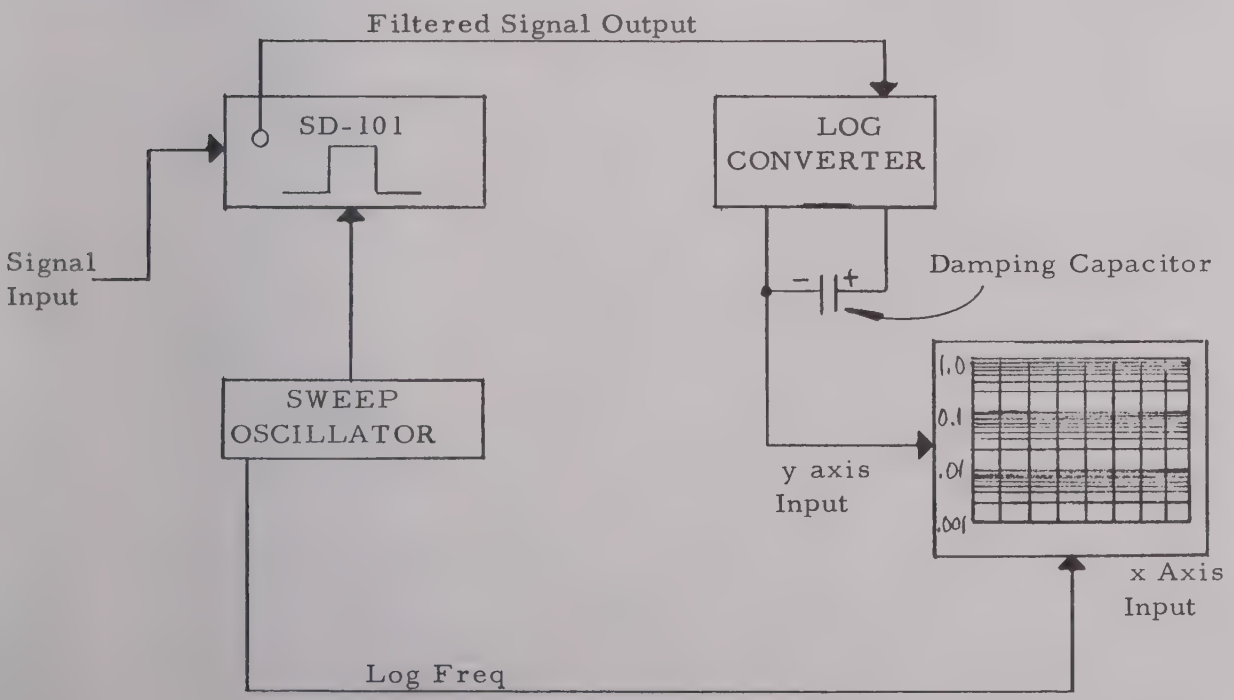
Cal= $\frac{(.7 \times 10)^2}{17.6}$ $\frac{49 \text{ g}^2}{17.6 \text{ cps}}$ = 2.88 or 2.9 g^2/ cps

Note: Only the "RANGE" control has any effect on the filtered output. This is why the "MULTIPLIER" does not enter into the calculation.

During operation, if it is desired to increase the sensitivity 10 to 1, change the Ballantine attenuator 10 db to a more sensitive scale.

Setup #2 can be used to plot out the squared response of the filters.

SETUP #3:



CALIBRATION OF SD-101 FOR PSD ANALYSIS

SETUP 3 (Continued)

CONTROL KNOB SETTINGS

The setup and calibration procedure is basically the same as for Setup #1. The differences are as follows:

(a) Operate the Log Converter in the "AC" mode.

(b) The lower frequency limit is 20 cps due to the frequency response of the Log Converter.

(c)

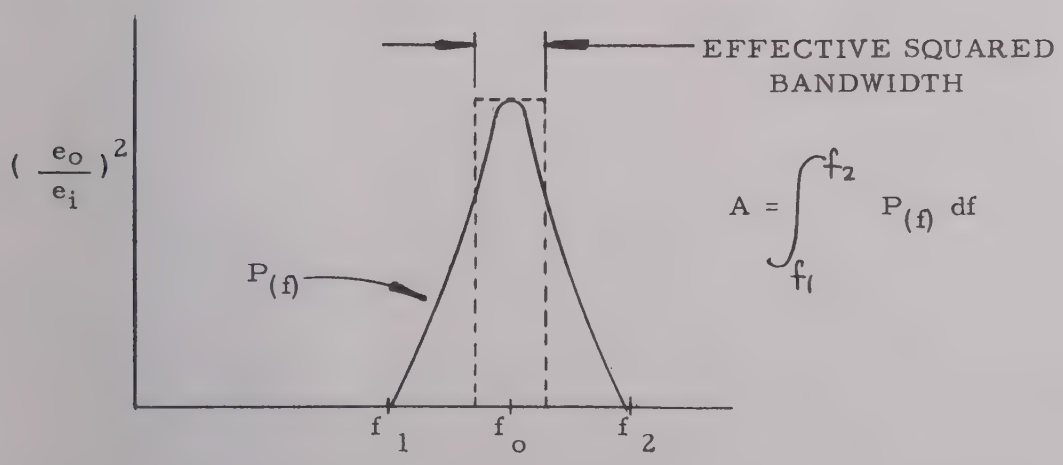
$$\text{Cal} = \frac{(.637 \text{ full scale})^2}{\text{Effective squared bandwidth}}$$

$$\text{Full Scale} = \frac{\text{SD-101 Range (millivolts)}}{\text{Pickup sensitivity (millivolts/g)}}$$

Note: The filtered signal output is capable of delivering 7 volts into the Log Converter. Cut the output down until the Log Converter meter is indicating approximately 5 db.

Setup #3 is normally used when the chopper in the Log Converter is not functioning or wider dynamic range is required for plotting rms/g/cps levels.

CALCULATION OF EFFECTIVE SQUARED BANDWIDTH

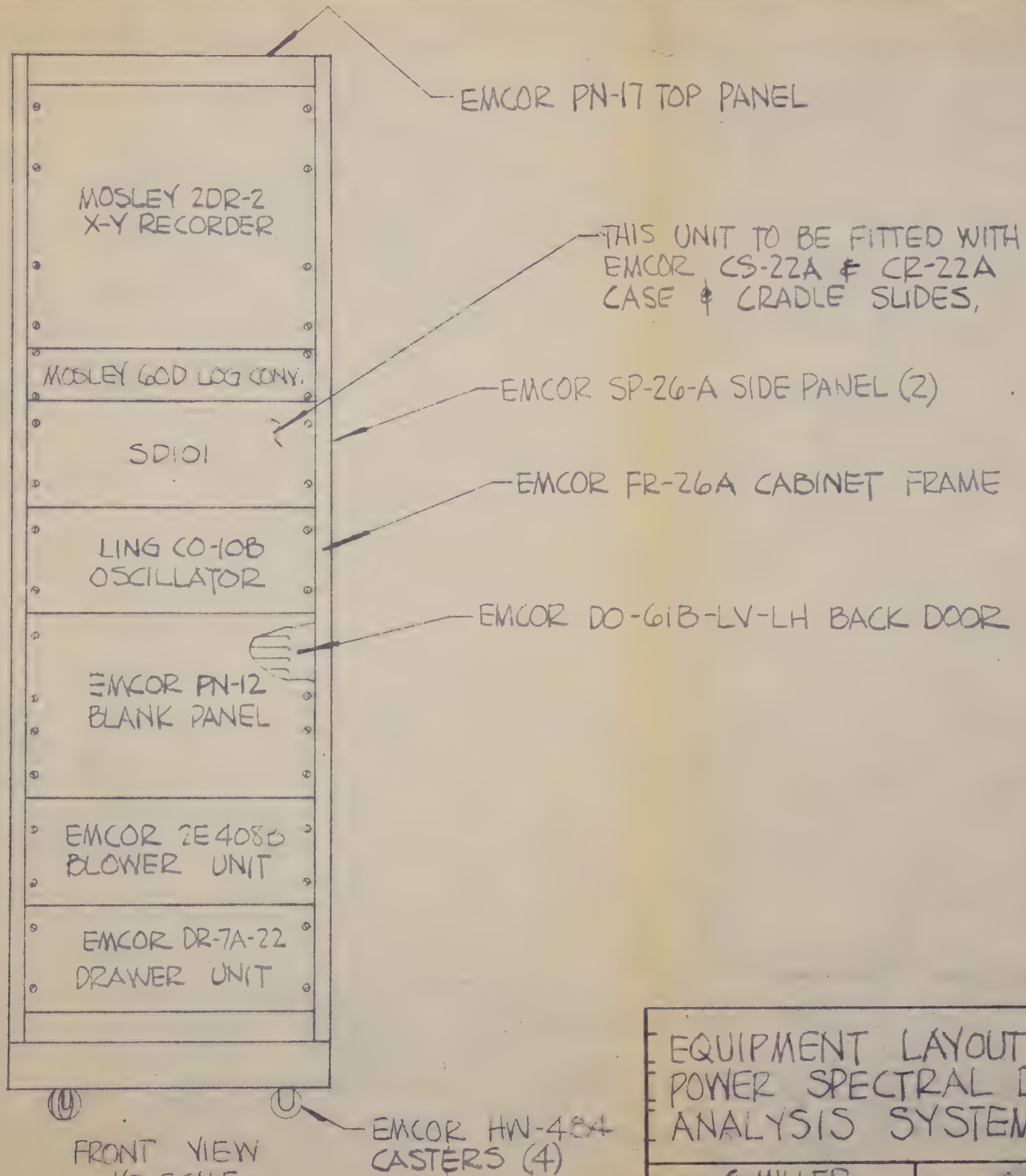


CALCUALTION OF EFFECTIVE SQUARED BANDWIDTH (Continued)

(a) Plot the squared response characteristics of the filter on linear paper.

(b) Integrate the curve to find the total area.

(c) Construct a rectangle of the same height containing the same area. The width of the rectangle is the effective squared bandwidth.

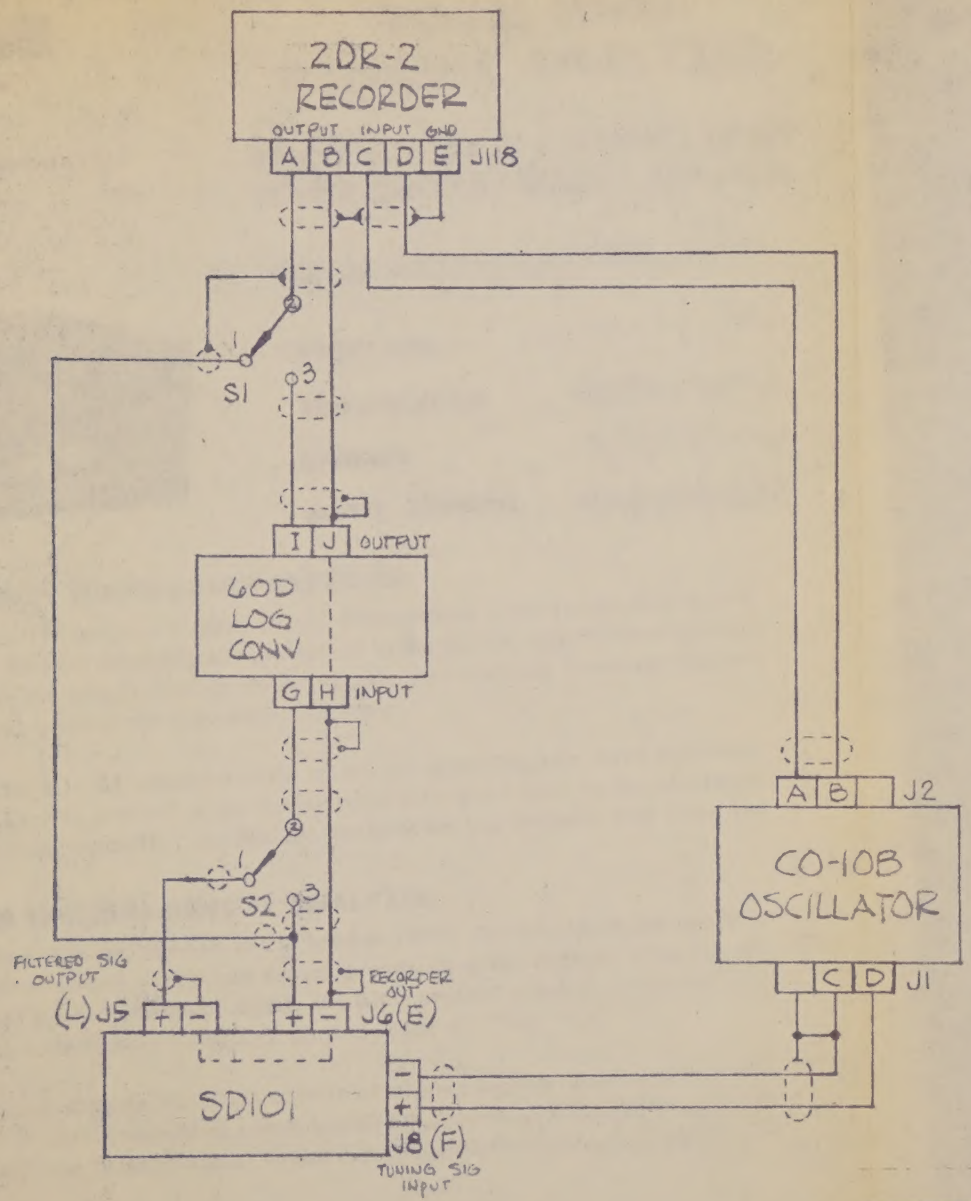


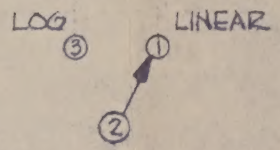
EQUIPMENT LAYOUT-
POWER SPECTRAL DENSITY
ANALYSIS SYSTEM

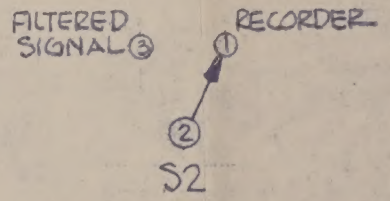
SPECTRAL DYNAMICS CORPORATION
OF SAN DIEGO

13 SK62062 REV.

DRAWN G. MILLER | APPROVED | SHEET 1 OF 2 | CODE IDENT







WIRING DIAGRAM -
POWER SPECTRAL DENSITY
ANALYSIS SYSTEM

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OF SAN DIEGO

13 SK62062 REV.

DRAWN G. MILLER APPROVED

SHEET 2 OF 2 CODE IDENT

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MODEL SD-101 DYNAMIC ANALYZER

SPECTRAL DYNAMICS CORPORATION
OF SAN DIEGO

FREQUENCY TUNED BANDPASS FILTER POWER SPECTRAL DENSITY ANALYZER

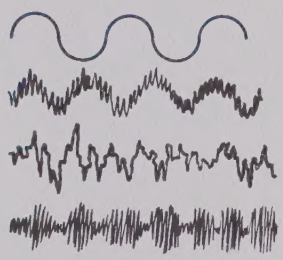
FOR SHAKER SYSTEMS TESTING WITH

SWEPT SINE

SINE – RANDOM

RANDOM

SWEPT RANDOM



SD–101 as a FREQUENCY TUNED BANDPASS FILTER

SWEPT SINE --- The SD-101 frequency tuned filter, when placed in the feedback loop of a shaker system, tracks the excitation frequency applied to the shaker and removes distortion and noise contained in the accelerometer output signal; thus allowing measurement and control of the fundamental input to the specimen under test.

SINE - RANDOM --- The SD-101 synchronously tracks the traveling sine wave and band-limits the noise; thus allowing control of the fundamental sine wave input to the specimen. By the use of special external circuitry, the SD-101 can provide two outputs; Sine Pass and Sine Reject.

SD-101 as a POWER SPECTRAL DENSITY ANALYZER

RANDOM --- As a PSD Analyzer, the SD-101 is used to verify random spectrum applied, analyze specimen response and to verify and assist in equalizing the shaker. The SD-101 provides a linear DC and a filtered signal output, and when applied to a log converter, calibrated to 2 log (g), provides signals to an X-Y plotter of log g^2 CPS.

SWEPT RANDOM --- Connecting the SD-101 to a white or shaped random source and sweeping the tuning frequency with a standard sweep oscillator, provides selectable bandwidth swept random signals at the filtered signal output for swept random and swept random on random tests.

SPECIAL FEATURES:

* SD-101 may be tuned by any external sine wave source such as: audio and sub-audio oscillators, tape recorders, telemetering signals, tachometer pickups, etc.
* Rugged high reliability construction and components.
* Wide dynamic range.
* Tuned by existing audio sweep oscillators.
* Phase coherent filtered output signal for use with existing feedback control.
* DC analog of the filtered signal level for plotting systems.
* Inherently frequency tuned - no integrating or frequency to DC conversion used.
* Wide selection of filter bandwidths.
* Exceptionally steep sided filters.